

Syrian Arab Republic

Ministry of Education and Higher Education

Arab University for Science and Technology

Faculty of Computer Engineering



Third-(Part 2) Lecture

Modeling & Simulation

Lecturer Introduction

Dr. Radwan Sobhi Al-Mohammad

Agenda

- **Queueing Model.**
- **Queueing System Algorithms.**
- **Interarrival & Service Time.**
- **Idle & Busy System.**
- **Single Server Queue.**

- Single Server Queue:

Simulation System						Performance Measure		
Customer	Interarrival Time [Minutes]	Arrival Time [Clock]	Service Time [Minutes]	Time Service Begins [Clock]	Time Service Ends [Clock]	Waiting Time in Queue [Minutes]	Time Customer in System [Minutes]	Idle Time of Server [Minutes]
1	—	0	4	0				
2	8		1					
3	6		4					
4	1		3					
5	8		2					
6	3		4					
7	8		5					
8	7		4					
9	2		5					
10	3		3					
11	1		3					
12	1		5					
13	5		4					
14	6		1					
15	3		5					
16	8		4					
17	1		3					
18	2		3					
19	4		2					
20	5		3					
Total	82		68					

Simulation System

Performance Measure

Customer	Interarrival Time [Minutes]	Arrival Time [Clock]	Service Time [Minutes]	Time Service Begins [Clock]	Time Service Ends [Clock]	Waiting Time in Queue [Minutes]	Time Customer in System [Minutes]	Idle Time of Server [Minutes]
1	—	0	4	0	4	0	4	0
2	8	8	1	8	9	0	1	4
3	6	14	4	14	18	0	4	5
4	1	15	3	18	21	3	6	0
5	8	23	2	23	25	0	2	2
6	3	26	4	26	30	0	4	1
7	8	34	5	34	39	0	5	4
8	7	41	4	41	45	0	4	2
9	2	43	5	45	50	2	7	0
10	3	46	3	50	53	4	7	0
11	1	47	3	53	56	6	9	0
12	1	48	5	56	61	8	13	0
13	5	53	4	61	65	8	12	0
14	6	59	1	65	66	6	7	0
15	3	62	5	66	71	4	9	0
16	8	70	4	71	75	1	5	0
17	1	71	3	75	78	4	7	0
18	2	73	3	78	81	5	8	0
19	4	77	2	81	83	4	6	0
20	5	82	3	83	86	1	4	0
Total	82		68			56	124	18

Performance Parameters:

a) Average Service Time:

$$\begin{array}{l} \text{average service time} \\ \text{(minutes)} \end{array} = \frac{\text{total service time (minutes)}}{\text{total number of customers}}$$

$$= \frac{68}{20} = 3.4 \text{ minutes}$$

The verification process can be performed by comparison with the mean, which can be calculated using the following formula:

$$E(S) = \sum_{s=0}^{\infty} sp(s)$$

$$= 1(0.10) + 2(0.20) + 3(0.30) + 4(0.25) + 5(0.10) + 6(0.05)$$

$$= 3.2 \text{ minutes}$$

b) Average arrivals Time:

$$\text{average time between arrivals (minutes)} = \frac{\text{sum of all times between arrivals (minutes)}}{\text{number of arrivals} - 1}$$

$$= \frac{82}{19} = 4.3 \text{ minutes}$$

The verification process can be performed by comparison with the mean, which can be calculated using the following formula:

$$E(S) = \sum_{s=0}^{\infty} sp(s)$$

$$E(A) = \frac{a + b}{2} = \frac{1 + 8}{2} = 4.5 \text{ minutes}$$

c) Average Waiting Time:

$$\text{average waiting time (minutes)} = \frac{\text{total time customers wait in queue (minutes)}}{\text{total numbers of customers}}$$

$$= \frac{56}{20} = 2.8 \text{ minutes}$$

Special Case (1):

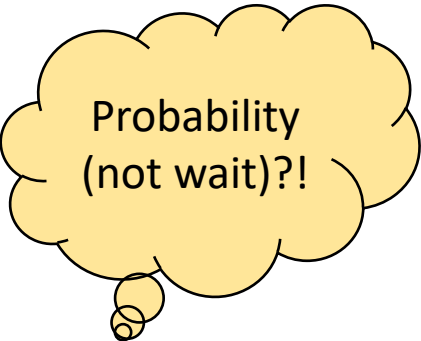
$$\text{Average waiting time of those who wait (minutes)} = \frac{\text{total time customers wait in queue (minutes)}}{\text{total number of customers who wait}}$$

$$= \frac{56}{13} = 4.3 \text{ minutes}$$

Special Case (2):

$$\text{probability (wait)} = \frac{\text{number of customers who wait}}{\text{total number of customers}}$$

$$= \frac{13}{20} = 0.65$$



Probability
(not wait)?!

d) Server Idle Probability:

$$\begin{array}{l} \text{probability of idle} \\ \text{server} \end{array} = \frac{\text{total idle time of server (minutes)}}{\text{total run time of simulation (minutes)}}$$

$$= \frac{18}{86} = 0.21$$

e) Average Time a Customer Spends in the System:

$$\begin{array}{l} \text{average time customer} \\ \text{spends in the system} \\ \text{(minutes)} \end{array} = \frac{\begin{array}{l} \text{total time customers spend in the} \\ \text{system (minutes)} \end{array}}{\text{total number of customers}}$$

$$= \frac{124}{20} = 6.2 \text{ minutes}$$

The second way of computing this same result is to realize that the following relationship must hold:

$$\begin{array}{l} \text{average time} \\ \text{customer spends} \\ \text{in the system} \\ \text{(minutes)} \end{array} = \begin{array}{l} \text{average time} \\ \text{customer spends} \\ \text{waiting in the} \\ \text{queue (minutes)} \end{array} + \begin{array}{l} \text{average time} \\ \text{customer spends} \\ \text{in service} \\ \text{(minutes)} \end{array}$$

$$= 2.8 + 3.4 = 6.2 \text{ minutes}$$

Thank you for listening